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Risk analysis of extended pancreas donor selection criteria

Jacobus W. Mensink [a, b, *], Kirsten M. de Vries [b], Volkert A.L. Huurman [a], Robert A. Pol [c], Ian P.J. Alwayn [a], Andries E. Braat [a]

[a] Department of Transplant Surgery, LUMC, Leiden University, the Netherlands
[b] Dutch Transplant Foundation, Leiden, the Netherlands
[c] Department of Transplant Surgery, UMCG, Groningen University, the Netherlands

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ABSTRACT

Introduction: The success of pancreas transplantation, in combination with a stable number of available allografts has resulted in an increasing waiting list. This study investigated donor potential by expanding age and Body Mass Index (BMI) criteria.
Methods: All reported donors in the Netherlands between 2013 and 2017 were analysed. Risk assessment of extended criteria donors was done by in-depth analysis of donor reports and calculation of the Pancreas Donor Risk Index (PDRI). The PDRI of these extended criteria donors was compared to standard criteria donors to evaluate the increased risk on graft failure.
Results: A total of 1273 donors were reported. Of these donors, 405 donors were reported as pancreas donor, of which 93 (23%) pancreata were transplanted. Extending age criterion with 5 years could result in additional 40 Donation after Brain Death donors and 37 Donation after Circulatory Death donors reported. In 24 (31%) extended age criteria donors the PDRI was below the upper limit of currently transplanted pancreata. Extending BMI criteria to 35 kg/m^2 could result in an additional 19 (6%) donors reported.
Conclusions: Extending BMI criteria could result in a slight increase of reported donors. Extending age criteria increased significantly the number of reported donors. In 24 (31%) of the older donors the PDRI showed a reduced risk compared to currently transplanted pancreata. This study suggest that, if other risk factors are absent, pancreata of extended age and/or BMI criteria donors should be considered for transplantation.

Introduction

In more than 50 years of pancreas transplantation, simultaneous transplantation of pancreas and kidney (SPK) proved itself a curative and successful treatment for type 1 diabetic patients with end-stage renal failure [1]. However, the success of this procedure results in an increasing number of patients on the waiting list for pancreas transplantation. In the Netherlands and Eurotransplant (ET) region the number of pancreas donors is relatively stable but the median time on the waiting list is increasing. Another concerning fact is the increasing median age of donors [2]. Furthermore, the risk of postoperative complications and graft loss probably explains the conservative and risk averse pancreas acceptance policy in most transplant centers. A common argument for strict pancreas allograft selection is that, unlike kidney and liver transplantation, it is not considered an immediate lifesaving procedure. However, SPK shows better patient survival as compared to kidney transplant alone (KTA) [3]. The reduced cardiovascular mortality and morbidity in SPK, as compared to KTA, is considered to be an important factor in the improved mortality rates reported after SPK [4]. Additionally, SPK has a beneficial effect on reversing systemic microvascular structural abnormalities caused by Diabetes Mellitus (DM) [5]. A retrospective analysis of a large donor cohort in the United Network for Organ Sharing (UNOS) region showed median patient survival of patients on the waiting list for SPK of 4.2 years, as compared to a median patient survival of 14.5 years after SPK [6].

Pancreas donor selection criteria in the Netherlands are based on a Body Mass Index (BMI) cut-off of <30 kg/m^2 and an age upper-limit of ≤60 years in Donation after Brain Dead (DBD) donors and

* Corresponding author. Department of Surgery, Division of Transplantation, Leiden University Medical Center, Albinusdreef 2, 2333 ZA, Leiden, the Netherlands.
E-mail address: j.w.mensink@lumc.nl (J.W. Mensink).

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Abbreviations

BMI	Body Mass Index
CIT	Cold Ischemic Time
CVA	Cerebrovascular Accident
DBD	Donation after Brain Death
DCD	Donation after Circulatory Death
DM	Diabetes Mellitus
ENIS	Eurotransplant Network Information System
ET	Eurotransplant
ICU	Intensive Care Unit
KTA	Kidney Transplantation Alone
OPI	Organ Procurement Information
PDRI	Pancreas Donor Risk Index
SD	Standard Deviation
SPK	Simultaneous Transplantation of Pancreas and Kidney
UNOS	United Network for Organ Sharing

≤50 years in Donation after Circulatory Death (DCD) donors [7]. If not accepted for vascularized organ donation, the organ is initially considered for islet isolation. If the pancreas is declined for islet isolation, the organ is considered for research [7]. Despite having an increased risk of graft failure as compared to DBD donors, DCD donors for vascularized pancreas transplantation have proven to be a successful option in reducing the shortage of donor organs, given that other risk factors are limited [8–10]. In a large database analysis in the UNOS region 10 statistically significantly risk factors for increased pancreas allograft failure were identified: increased age, BMI >25 kg/m^2, cause of death being cerebrovascular accident (CVA), type of pancreas transplantation other than SPK, DCD donation, male gender, lower height, non-Caucasian race, prolonged pancreas preservation time and terminal serum creatinine level >2.5 mg/dl. These factors were weighed and combined in a continuous risk score: the Pancreas Donor Risk Index (PDRI) [11]. The predictive capacity of the PDRI for graft survival has been validated in the United Kingdom, the Netherlands and Germany [12–14]. The PDRI is also considered to be a useful tool in donor selection. The c-statistics for organ reporting, acceptance and transplantation are 0.78, 0.79 and 0.84 respectively [15]. As well as DCD donation, donor obesity (BMI >30 kg/m^2) results in a relative risk factor of 1.66 for pancreas graft failure compared to non-obese donors (BMI <30 kg/m^2) [16]. However, recent literature suggests there is a difference in graft survival between mildly obese donors (BMI 30–35 kg/m^2) and severely obese donors (BMI >35 kg/m^2) [17]. No difference in graft failure was found between lean (BMI <25 kg/m^2) and mildly obese donors, whereas severe obesity was associated with 37% increased risk of pancreas failure compared to lean donors. Compared to the non-inferior graft survival in extended BMI criteria donors and DCD donation, we hypothesize that pancreas allografts from older donors could yield good transplantation outcomes, if other risk factors are minimized.

With the persistent shortage of good quality pancreata, combined with the improved patient survival after pancreas transplantation, it is becoming increasingly important to evaluate the current pancreas donor selection and to investigate the possibility of applying extended donor selection criteria. It is assumed that not every suitable donor in the Netherlands is reported and accepted, partially because of too strict age and BMI limits. In this study we re-evaluated all potential pancreas donors and the current number of reported, accepted, procured and transplanted pancreas allografts in the Netherlands. Risk analysis was done by thoroughly re-analysing all donor reports and calculating the PDRI. By extending age and BMI limits this study provides insight in unutilized potential donor and aims to contribute to the pancreas allograft availability.

Patients and methods

Study design

The retrospective cohort study included all patients reported as organ donor in The Netherlands between January 1st, 2014 and December 31st, 2017. Donors with an age <16 years were excluded. Donor characteristics were extracted from the ET Information Network System (ENIS) database and Organ Procurement Information (OPI) database from the Dutch Transplant Foundation. Two methods were used to distinguish between the absolute number of potential donors and more adequate selection of the extended criteria donors. First, donors without DM, BMI <30 kg/m^2 and their general medical condition being sufficient to donate their liver and at least one kidney were selected. This method selected all patients without general contra-indications for donation and without any major health problems. The second method to approach a more adequate donor potential in extended age criteria was to re-analyse donor reports of all DCD donors >50 years and DBD donors >60 years. Clinical course during admittance, medical history, serum amylase and history of alcohol or nicotine abuse were evaluated in relation to donor suitability. The PDRI was calculated in all pancreas and potential pancreas donors. To calculate the PDRI of potential pancreas donors that were not transplanted, type of transplantation, ethnicity of the donor and cold ischemic time (CIT) were set at reference and mean, respectively SPK, Caucasian and 9.6 h. To compare the risks factors of the PDRI for all potential donors except their age, the PDRI was calculated with reference age of 28 years.

Statistical analysis

Categorical data are presented as absolute number (%) and continuous data are presented as mean ± standard deviation (SD) unless otherwise stated. P values less than 0.05 were considered statistically significant. Differences between two groups with skewed continuous data were assessed using Mann-Whitney *U* test. For analysing differences in categorical data Chi-Square test was used. All statistical analysis were performed using IBM SPSS Statistics for Windows (IBM Corp. Released 2016. Version 24.0. Armonk, NY).

Results

Our donor cohort included 1273 potential organ donors, of which 405 donors were reported for vascularized pancreas transplantation. More than half of the reported pancreas donors were accepted by the transplant physician. Of the reported pancreas donors 160 pancreata (40%) were procured and eventually in 93 (23%) cases the pancreas was transplanted as vascularized organ. Pancreas allografts not selected for vascularized organ transplantation are generally offered for islet isolation, scientific research, discarded or left in the donor. Characteristics of the donors selected for vascularized pancreas transplantation are shown in Table 1. In the analysis of all reported pancreas donors, medical history of hypertension or DM were missing in 9 cases and 1 case respectively. Not every pancreas allograft of a potential organ donor between the age of 16 and 60, is reported, accepted, procured and transplanted. As shown in Table 2, based on age criteria alone, respectively 68 (21%) and 25 (11%) potential DBD and DCD donors were transplanted. In a more strict donor selection (donors without

Table 1
Characteristics of vascularized pancreas donor selection.

	Reported N = 405	Accepted N = 214	Procured N = 160	Transplanted N = 93
Age (years)	42.3 (12.6 SD)	40.1 (12.7 SD)	39.8 (12.8 SD)	36.4 (11.8 SD)
Female	197 (49%)	103 (48%)	82 (51%)	54 (58%)
DCD type of donor	163 (40%)	72 (34%)	45 (28%)	25 (27%)
BMI (kg/m^2)	24.7 (4.1 SD)	23.8 (3.0 SD)	23.9 (2.9 SD)	23.6 (2.6 SD)
Cause of death				
CVA	199 (49%)	113 (53%)	85 (53%)	46 (50%)
Trauma	87 (22%)	55 (26%)	41 (26%)	30 (32%)
Other	119 (29%)	46 (21%)	34 (21%)	17 (18%)
Hypertension	65 (16%)	24 (11%)	13 (8%)	8 (9%)
Diabetes mellitus	9 (2%)	0	0	0
Creatinine (mg/dl)	0.93 (0.86 SD)	0.83 (0.64 SD)	0.85 (0.68 SD)	0.80 (0.64 SD)
PDRI	1.89 (0.71 SD)	1.67 (0.57 SD)	1.62 (0.55 SD)	1.44 (0.45 SD)
CIT Pancreas (hours)	–	–	–	9.6 (2.4)

BMI, Body Mass Index; CIT, Cold Ischemic Time; CVA, CerebroVascular Accident; DCD, Donation after Circulatory Death; PDRI, Pancreas Donor Risk Index.

Table 2
Selection of potential pancreas donors versus selection of actual pancreas donors.

	Selection based on age		Selection age + BMI <30 + no DM + Liver & ≥1 Kidney Transplantation	
	16–60 years	16–50 years		
	DBD (%)	DCD (%)	DBD (%)	DCD (%)
Potential organ donors	325 (100%)	232 (100%)	226 (100%)	87 (100%)
Pancreata reported	231 (71%)	146 (63%)	185 (82%)	66 (76%)
Pancreata accepted	141 (43%)	68 (29%)	124 (55%)	36 (41%)
Pancreata procured	114 (35%)	44 (19%)	105 (46%)	30 (34%)
Pancreata transplanted	68 (21%)	25 (11%)	67 (30%)	19 (22%)

BMI, Body Mass Index; DBD, Donation after Brain Death; DCD, Donation after Circulatory Death; DM, Diabetes Mellitus.

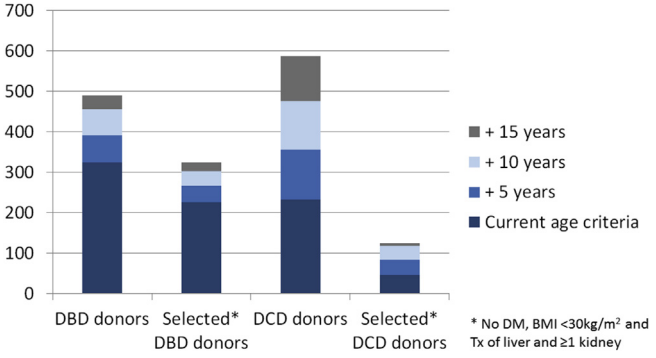

Fig. 1. Donor potential with extended age criteria in DBD and DCD donors.

DM, with BMI <30 kg/m^2 and transplantation of the liver and at least one kidney) the transplantation rates increased. Of these selected donors, 67 (30%) DBD and 19 (22%) DCD donors were actually transplanted. Reasons for not accepting, procuring or transplanting a reported pancreas of a potential donor were; the donors' hemodynamic instability; no consent; BMI >30; a medical history of DM; prolonged agonal phase in DCD donation >60 min; elevated serum amylase; suspicion of malignancy; pancreatitis; pancreatic cysts; liver fibrosis and/or steatosis; pancreatic hematomas; procurement damage; atherosclerosis; anatomical variations; or a combination of these contra-indications. The 67 pancreata not used for vascularized transplantation were offered for islet isolation. If declined for islet isolation, the pancreata were offered for research purposes. Not approved pancreata for research were left with the donor. Of all procured organs 4 pancreata (6%) were not transplanted as vascularized organ due to procurement damage. Interestingly, 7 pancreata were transplanted of donors that did not donate their liver or kidneys; 4 DCD donors and 1 DBD donor without liver donation and 2 DCD donors without kidney donation.

Extending age criteria

Fig. 1 shows the number of potential pancreas donors when extending age limits in DBD and DCD donors. For example, if the upper age limit is raised with 5 years–65, there is an absolute increase of 67 (21%) and 124 (53%) potential DBD and DCD donors respectively. Of this absolute number of potential donors, donors without DM, BMI <30 kg/m2 and donor quality being sufficient for transplanting the liver and at least one kidney were selected. After correcting for these absolute and relative contra-indications for pancreas transplantation the potential increase of donors reported would be 40 (18%) DBD pancreata and 37 (43%) DCD pancreata. Tables 3 and 4 show the number of potential pancreas donors and corresponding PDRI in extended age criteria. The last columns of Tables 3 and 4 show the difference between the PDRI calculated with and without age as risk factor. This analysis shows that the increased PDRI in the selected donors (BMI <30 kg/m^2, no DM and transplantation of the liver and at least one kidney) is almost exclusively the result of increased age. For example, donors between 61 and 65 years of age DBD donors have a mean PDRI of 2.69, as compared to 1.71 for donors between 41 and 50 years of age. When excluding age from the PDRI equation, the difference in PDRI between DBD donors 41–50 years of age versus donors 61–65 years of age is only 0.02 (1.05 versus 1.07, Table 3). Further analysis of these potential cases based on medical history, clinical course during admission, serum amylase levels and social history of intoxications results in a more realistic number of potential donors. When, for example, increasing age criteria with 10 years in potential DBD and DCD donors, in respectively 35 (45%) and 46 (64%) potential donors no absolute contra-indication could be found in the donor report.

Extending BMI criteria

Table 5 shows the number of potential donors by increasing BMI criteria in pancreas donor selection. If the BMI limit is extended ≥40 kg/m^2 in current age criteria, donor potential increases with 53 (11%) DCD and DBD donors. Extending BMI criteria in potential pancreas donors without DM and with transplantation of the liver and at least one kidney results in an increase of 24 (7%) additional pancreas donors reported.

Table 3
Absolute and relative number of potential DBD donors in extended age criteria.

Age	DBD Selection based on age 0–70 years				DBD selection based on BMI<30 + no DM + Liver & ≥1 Kidney Tx				
	Freq.	PDRI (SD)	Cum. Freq.	Cum. %	Freq.	PDRI (SD)	Cum. Freq.	Cum. %	Calc. PDRI (SD) without age
16–40	89	1.07 (0.25)	89	27%	68	1.02 (0.20)	68	30%	0.98 (0.11)
41–50	97	1.81 (0.32)	186	57%	62	1.71 (0.23)	130	58%	1.05 (0.11)
51–60	139	2.30 (0.46)	325	100%	96	2.21 (0.27)	226	100%	1.09 (0.11)
61–65	67	3.00 (0.68)	392	121%	40	2.69 (0.31)	266	118%	1.07 (0.12)
66–70	63	3.23 (0.43)	455	140%	37	3.15 (0.31)	303	134%	1.11 (0.10)
71–75	35	3.67 (0.50)	490	151%	21	3.48 (0.30)	324	143%	1.09 (0.08)

BMI, Body Mass Index; DBD, Donation after Brain Death; DM, Diabetes Mellitus; PDRI, Pancreas Donor Risk Index; SD, Standard Deviation; Tx, Transplantation.

Table 4
Absolute and relative number of potential DCD donors in extended age criteria.

Age	DCD Selection based on age 0–60 years				DCD selection based on BMI<30 + no DM + Liver & ≥1 Kidney Tx				
	Freq.	PDRI (SD)	Cum. Freq.	Cum. %	Freq.	PDRI (SD)	Cum. Freq.	Cum. %	Calc. PDRI (SD) without age
16–30	60	1.22 (0.19)	60	26%	29	1.18 (0.14)	29	33%	1.33 (0.15)
31–40	42	1.82 (0.40)	102	44%	11	1.64 (0.25)	40	46%	1.33 (0.18)
41–50	130	2.36 (0.45)	232	100%	47	2.22 (0.29)	87	100%	1.37 (0.15)
51–55	124	2.85 (0.49)	356	153%	37	2.70 (0.35)	124	143%	1.39 (0.17)
56–60	120	3.27 (0.54)	476	205%	35	3.22 (0.38)	159	183%	1.46 (0.17)
61–65	111	3.75 (0.78)	587	253%	6	3.40 (0.34)	165	190%	1.41 (0.12)

BMI, Body Mass Index; DCD, Donation after Circulatory Death; DM, Diabetes Mellitus; PDRI, Pancreas Donor Risk Index; SD, Standard Deviation; Tx, Transplantation.

Table 5
Absolute and relative number of potential donors in extended BMI criteria.

BMI	Selection based on BMI + age 16-60 16–50 years				Selection BMI<30 + age + no DM + Liver & ≥1 Kidney Transplantation			
	DBD	DCD	Cum. Freq.	Cum. %	DBD	DCD	Cum. Freq.	Cum. %
<20	19	21	40	8%	14	11	25	8%
20–25	159	114	313	62%	127	48	200	62%
25–30	115	76	504	100%	91	30	321	100%
31–35	24	14	542	108%	16	3	340	106%
36–40	6	4	552	110%	4	1	345	107%
>40	2	3	557	111%	0	0	345	107%

BMI, Body Mass Index; DBD, Donation after Brain Death; DCD, Donation after Circulatory Death' DM, Diabetes Mellitus.

Discussion

By extending age and/or BMI limits in pancreas donation, this study revealed a large hidden donor potential. We admit extending donor selection criteria generates a slight increased risk on graft failure, shown in Tables 3–5 by the increased PDRI of extended criteria donors. Expanding age criteria shows a significant increase in potential donors in which DCD donors (43%) have a higher potential than DBD donors (18%). Calculations based on the current transplantation rate, as depicted in Table 3, show that extending age criteria with 5 years may result in transplanting 3 extra DBD and 2 extra DCD good quality pancreata per year. Of course, the transplantation rate may be lower for older donors as compared to the current donor selection. But even when the transplantation rate is, for example, only half of the current rate, extending age criteria with 5 years could result in an increase of 2–3 (11%) pancreas transplantations in the Netherlands alone. An increase of 19 (6%) good quality pancreas donors reported is expected when extending the limit BMI ≤30 to ≤35 kg/m^2. Extending BMI criteria to increase donor potential does not add the same number as compared to extending age criteria. This limited attribution was also found by *Proneth* et al., including only 1 donor with extended BMI criteria in the Extended Pancreas Donor Program Study [18]. *Alhamad* et al. showed no difference in graft survival between BMI <25 and BMI 30–35 kg/m^2 [17]. Extending BMI criteria to <35 kg/m^2 may be a safe way to expand donor selection criteria and could be part of the solution to meet the increasing waiting lists. The increased risk of extended criteria donors should be weighed against the number of patients still on the waiting list. A large retrospective study in the UNOS region in more than half a million solid organ recipients showed the clear benefits of pancreas transplantation [6]. In SPK the benefit gained by transplantation was 4.6 observed life-years saved per patient to date as compared to patients on the wait list. A significant difference in patient survival after pancreas transplantation was also shown by *Dellen* et al. with 30% mortality on the waiting list and 9% mortality of post-transplantation patients in 2 years of follow-up [19]. By increasing age criteria in pancreas donor selection the transplantation rate of donors reported may decrease, but the absolute number of transplantations will increase. The relative number of cases without consent or the number of potential donors with a prolonged agonal phase in DCD donation will probably remain the same when age criteria are extended. However, donor age being a risk factor for organ procurement damage, extended age criteria donors may result in more organ retrieval related injuries and subsequently a higher discard rate compared to younger donors [20]. On the other hand, it could be compensated by the advantage of the expected increased number of procurements and transplantations. Increased experience will result in less organ retrieval related injuries [21]. Not all procuring surgeons in the Netherlands are performing pancreas transplantations. However, since 2010 professional abdominal organ recovery training is mandatory, certification limited the number of procurement damages [21]. Furthermore, transplantation outcomes may improve because of increased experience in the centers by an increased number of transplantations. High volume centers show superior outcomes by transplanting allografts from donors as compared to low volume centers, even if pancreata with increased risk factors are transplanted [22–24]. In the Netherlands all academic hospitals are performing organ transplantations, but only two of the eight academic centers are performing pancreas

transplantations. Risk factors for pancreas graft survival have been described extensively in the literature. Nevertheless, it is not the single risk factor itself but the combined donor and recipient risk factors that make the reported pancreas allograft not suitable for transplantation. Again, using DCD allografts (instead of DBD allografts) for pancreas transplantation is a safe and established alternative to decrease the number of patients on the waiting list. An important study by *Muthusamy* et al. reported on transplant outcomes in a large donor cohort with DBD and DCD donor selection age criteria up to 60 years [8]. One year graft survival was not significantly different for DBD and DCD pancreata, 87% and 88% respectively. Increasing age in donor selection for liver and kidney donation is already an established way to increase transplantation numbers and subsequently decrease the waiting list [25,26]. Likewise, older donors without other risk factors may be suitable for pancreas transplantation and should be reported to and evaluated by a transplant physician [27,28]. Several studies showed the benefit of SPK vs KTA or SPK vs still being on the waiting list [3–6,11]. With the increased risk on graft failure after PAK/PTA versus SPK, Axelrod et al. suggest extended criteria donors should not be considered for PAK or PTA [11]. Besides extending donor selection criteria, other ways are being studied to optimize donor utilization and optimal organ selection. Normothermic regional perfusion during multi organ retrieval and normothermic machine perfusion after organ retrieval are means to optimize organ quality and assess organ function, especially in so called marginal organ donors [29,30].

This study has a few limitations that need to be addressed. First, the mean donor age in the study of *Axelrod* et al. is 26.3 years (10.8 SD). As shown in Fig. 2, the PDRI was developed (and validated) in a relative young donor cohort and may not be extrapolated to an older donor cohort [11]. Due to the current construction of the formula, the added risk of the factor age increases exponentially and therefore its attribution to the total score increases similarly. There is a large difference in the calculated PDRI with and without age, as shown in the last column of Tables 3 and 4 Of course, the PDRI without age is not a validated score and therefore cannot be used in predicting donor acceptance or graft survival. However, this example shows that age is the predominant contributing risk factor in the PDRI, especially in the extended criteria donors. The PDRI should be evaluated and adjusted for these extended age and/or BMI criteria donors. In general, increased donor age does increase the risk on graft failure. However, recent studies showed selected extended criteria pancreata could result in good transplant outcome [27,28]. Secondly, the PDRI is based on 9401 pancreas transplantations and corresponding outcome, representing only the currently reported and available donor factors. The risk averse organ acceptance policy of pancreas transplant surgeons resulted in a highly selective group of pancreata. Without analysing all discarded organs in the risk analysis, important donor risk factors might not be included in the donor risk index. The PDRI is, besides macroscopic evaluation of the allograft and experience of the transplantation center, only part of the information needed to make a decision. The decision to transplant the offered pancreas allograft is up to the discretion of the transplant physician. Third limitation is the retrospective and descriptive nature of our study, therefore not knowing the actual number of potential donors and corresponding transplantation outcomes of extended criteria pancreata. However, we used the PDRI to give an indication of the expected outcome of transplantation. Of the currently accepted and transplanted pancreas donors in the Netherlands the PDRI is up to 2.47. In this study an additional 24 (31%) potential donors with a PDRI below 2.47 could be reported if age criteria is extended with 5 years. The one year graft survival for PDRI 2.12–2.86 in a large UNOS cohort study is around 84%. [11] Mittal et al. reports on outcome after transplantation in a DBD and DCD donor cohort up to 60 years, partially including our extended age criteria DCD donors [12]. The PDRI of the 4th quartile was up to 3.40, corresponding with 1 year graft survival of 81%. Obviously, risk indexes of 3.40 (Mittal), 2.86 (Axelrod) or 2.47 (of transplanted pancreata in this donor cohort) are exceptionally high, and we think it might be a safer strategy to accept slightly older donors with a lower PDRI [11,12]. The selective use of extended criteria donors is non-inferior to standard criteria donors [27,28]. Extending age criteria with 5 years will result in a large additional number of donors reported. Extending BMI criteria up to 35 kg/m2 will only result in a small additional number of donors. With current limitations of donor selection, DBD donors >60 years, DCD donors >50 years and all potential donors with BMI >30 kg/m2 are not reported as potential pancreas donor at all. When other donor risk factors are absent and the combination of recipient characteristics, center experience and visual inspection of the pancreas is not prohibiting transplantation, we emphasize these extended criteria pancreata can be used for transplantation. This extension will likely be accompanied by little increased and acceptable risk. Naturally, there is need for constantly re-evaluating the number and quality of offered organs in relation to the waiting list. Transplantation outcomes of extended criteria donors should be monitored closely and be compared to current selection criteria donors. As mentioned before, the significant decrease in patient mortality after pancreas transplantation illustrate the need for suitable organs for pancreas transplantation. This risk analysis suggests that even a slight extension of donor selection criteria will give more patients access to a lifesaving pancreas transplantation.

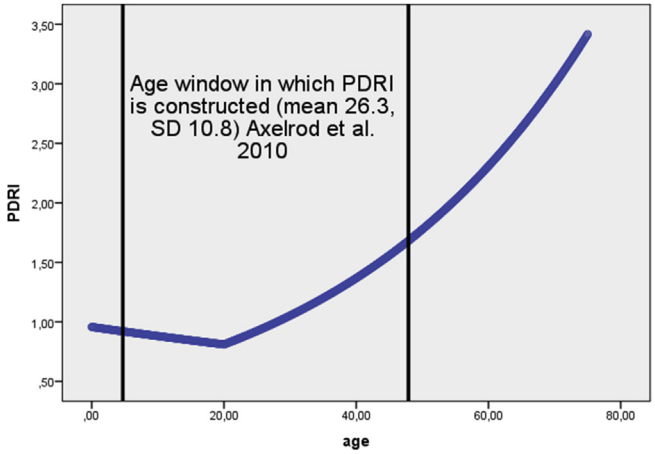

Fig. 2. PDRI calculated with all risk factors set at reference except for age.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pan.2019.08.010.

Authors contributions

AEB, IPJA and JWM participated in study design. AEB, JWM and KMV participated in data collection. AEB, JMW and VALH participated in data analysis. AEB, RAP and JWM participated in construction of the manuscript. All authors participated in critical revision of the manuscript.

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